Determination of Water Vapor for Stratospheric Observatory for Infrared Astronomy Aircraft (SOFIA)

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Our mission:

Is to accurately predict the water vapor loading is in the atmosphere which may further designate trajectory of SOFIA in order to have the best results in infrared astronomy observation.

Earth's Atmosphere, Altitude, and Water Vapor Existence:

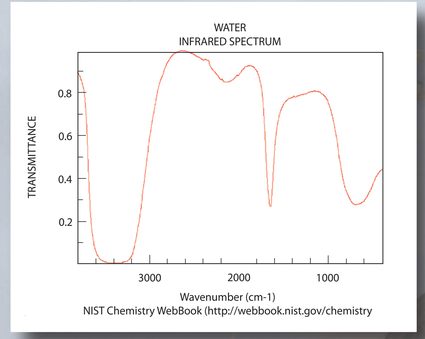
Earth's atmosphere reaches over 600 km (≈2 million ft) from the surface of the Earth. Only the lower atmospheric layer, Troposphere, contains the most of water vapor. This is the reason why SOFIA is flying above the Troposphere.

Tool – weather balloon atmospheric global model:

A weather balloon is used to measure the atmospheric parameter of pressure, temperature, humidity, and wind speed in the atmosphere. In order to obtain wind data, it is tracked by radar or navigation system, such as satellite based Global Positioning System (GPS).

The role of Water Vapor absorption in IR Astronomy

Water vapor = greenhouse gas, absorbs IR energy and re-emits the energy in all direction. Strong absorbance by water vapor occurs at wavelengths around 2900, 1950, and 1450 (nm), with other absorption all in the infrared spectrum. *Important* small percentage of water vapor in the atmosphere can still have a large influence on infrared absorption. The effect of water vapor absorption is important consideration because infrared astronomy is detecting infrared radiation emission.

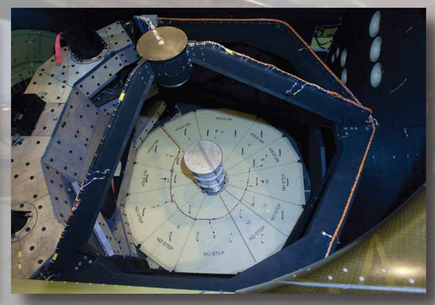


About SOFIA: The world largest airborne observatory that will complement the Hubble, Spitzer, Herschel an James Webb space telescopes and major Earth-based telescopes. It'll provide better image quality and vastly increased observational sensitivity. a joint program by NASA and DLR (German Aerospace Center). It is based out of NASA Dryden Palmdale Facility and will be flying globally.

NASA's Stratospheric Observatory for Infrared Astronomy 747SP reached a milestone Dec. 18, 2009, when the doors covering the aircraft's German-built infrared astronomy telescope were fully opened during flight. Dec. 18, 2009

NASA Photo / Carla Thomas

http://www.nasa.gov/mission_pages/SOFIA/multimedia/imagegallery/index.html#



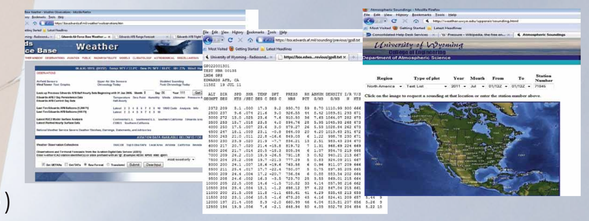
With a protective cover over its primary mirror, the high-tech German-built infrared telescope is nested in its framework inside the 19-foot-deep, 12-foot-wide telescope cavity in the rear fuselage of NASA's SOFIA flying observatory. April 20, 2010

NASA Photo / Tom Tschida

http://www.nasa.gov/mission_pages/SOFIA/multimedia/imagegallery/index.html#

Method:

- The current atmospheric model used for this project is the Global atmosphere model (Goddard Earth Observing System Model, Version 5(GEOS-5))from NASA Goddard Space Flight Center to determine the water loading.
- This is the comparison of two data sources: GEOS-5 (High Resolution as 0.5° latitude, 0.66° longitude) v.s. Actual Sounding Data (@ U. of Wyoming as 2° latitude, 2° longitude)

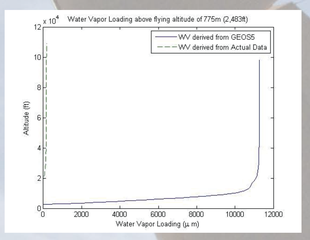


Formulae to Calculate Water Vapor Loading

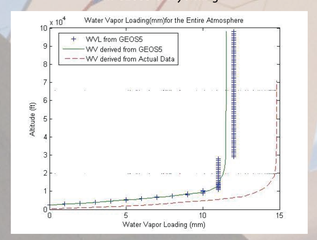
$$Water\quad Vapor\quad Loading = \frac{5}{980.616} * (W_{i+1} + W_i) * (P_i - P_{i+1})$$

Where 980.616 = acceleration of gravity (cm/s^2)
W = mixing ratio in grams per kilogram
P = pressure (millibars)
i = index ranging from the surface to the current level

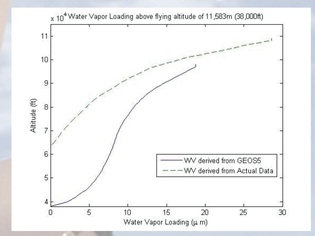
GEOS-5 vs. Actual Data from Wyoming



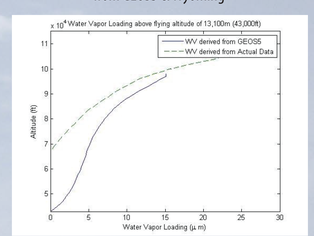
WVL Above SOFIA flying range775 km(2483ft) from GEOS5 & Wyoming



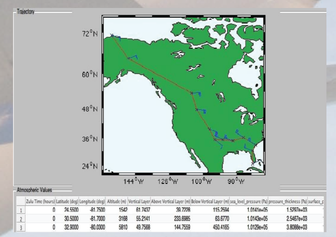
WVL Above SOFIA flying range11.5 km (38000ft) from GEOS5 & Wyoming



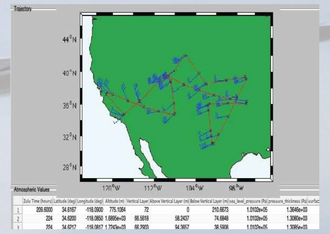
WVL Above SOFIA flying range13.1 km (41000ft) from GEOS5 & Wyoming



Christopher's contribution: list the atmospheric parameter and show the path of the flight.



Simulated data along a flight path from Florida to Alaska.



Actual data from SOFIA and its flight path

Conclusion:

- SOFIA may need to fly higher in order to reduce water vapor loading under 20μm.
- There is always a difference between model and actual data.
- Data from the model will be used to determine the amount of water vapor loading from the aircraft flight level to the top of the model (75km).

When the project is completed, it will provide an alternative atmospheric profile along the trajectory with the water vapor loading highlights.

Results & Discussion

Most of the upper air data provided in the United States are taken by the weather balloons. However, there isn't a lot data from the ocean. Once the flying region of SOFIA expands globally, water vapor loading in the atmosphere may become a concern because of the lack of measurements of atmospheric parameters needed to calculate water vapor loading. With more satellites being added to the space constellation and many to provide data on the earths atmosphere, it won't be long until satellites will be an additional source of atmospheric data.

Acknowledgement -

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Resources -

Roberts, E. R., Biberman, L. M., Selby, J. E.A. (1976). Infrared Continuum Absorption by Atmospheric Water Vapor in the 8 – 12 μm Window. Institute for Defense Analyses science and Technology Division, paper P-1134

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http://en.wikipedia.org/wiki/Water_vapor#Water_vapor_in_Earth.27s_atmosphere